

A CONSIDERATION OF THE ABILITY
OF PORT CHALMERS TO HANDLE
THE EXPECTED INCREASE IN
FOREST PRODUCTS EXPORTS FROM
THE OTAGO/SOUTHLAND REGION

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TABLE OF CONTENTS

	page
ABSTRACT	
1. INTRODUCTION	1
1.1 Port Chalmers: Forest Products Exports	1
1.2 Why Port Chalmers?	3
1.3 Why Log Exports?	5
1.4 Port Throughput 1986-2005	8
2. DESIGN PARAMETERS	9
2.1 Options	9
2.2 Method	10
2.3 Queuing Theory	11
2.4 Shipping	11
2.5 Loading Rates	12
2.6 Vessels Required to Clear Port Throughput	14
3. BASIS FOR CALCULATIONS	15
4. RESULTS AND ANALYSIS	16
4.1 Berth Occupancy	16
4.2 Waiting Times	18
4.3 Costs	20
4.3.1 Labour Considerations and Costs	20
4.3.2 Ship Waiting Costs	22
4.3.3 Total Waiting Costs	22
4.4 Analysis of Costs	24
5. COSTS OF PORT EXPANSION	26
5.1 Implications of the Cost Data	28
6. CONCLUSION	32
ACKNOWLEDGEMENTS	34
REFERENCES	35
APPENDICES	37
MAPS - Port Chalmers	
Otago Harbour	

LIST OF TABLES	page
Table 1 Port Chalmers Throughput 1986-2005	8
Table 2 Capacity of Log and Timber Carriers	12
Table 2.1 Log Loading Rate	12
Table 2.2 Sawn Timber Loading Rate	13
Table 2.3 Chipwood Loading Rate	13
Table 2.4 Loading Rates (Double Shift)	14
Table 2.5 Vessels Required to Clear Projected Throughput	14
Table 2.7 Berth Occupancy Limits	15
Table 2.8 Projected Costs for New Forestry Berths	27

LIST OF APPENDICES	
Appendix 1 Location of the Resource	37
Appendix 2 Port Throughput	39
Appendix 3 Queuing Theory	40
Appendix 4 Trends in World Shipping	43
Appendix 5 Calculation of the Average Waiting Cost	46

ABSTRACT

The Southland/Otago region is expected to significantly increase its exports of forest products over the next three decades. It is envisaged that at least 90% of this increase will flow through Port Chalmers. The effects of this increased throughput on the Port has been evaluated using a number of different factors, i.e. loading rates, number of berths and vessel draught in conjunction with the branch of operations research known as queuing theory. This combination has been used to determine the cost of delays to shipping as a result of Port congestion, i.e. waiting time and costs.

The results were that a considerable strain will be placed on the existing berthage by 1991 and that to alleviate serious congestion an expansion of port facilities must be undertaken.

To effectively cope with the projected throughput it was concluded that by 2001 a further three berths need to be provided and that by 1996 the Port should be introducing a double shift loading operation for forest products.

It appeared that harbour depth had very little importance if a high loading rate was used, the implication is that the loading rate governs Port throughput. There is unfortunately a very high labour cost which tends to diminish the savings in waiting costs made by having a double shift loading operation.

1. INTRODUCTION

The purpose of this report is to give some indication of the problems facing New Zealand ports with regard to forest products exports over the next three decades. Although there have been at least three major studies on the need for forestry ports, no study has looked closely at the option of exporting unprocessed products, i.e. logs and chips through an existing port and the problems this will cause. This study looks at the export of logs, chips and sawn timber through an established Port, Port Chalmers, and evaluates a 'status quo' option of keeping the present port draught and an option which radically alters the draught to cater for the largest projected forest products carrying vessels. Although this approach fails to take into account harbour depths at points of offloading i.e. destinations, it gives an indication of the effects of large bulk carriers on port throughput. Consideration is also taken of a double shift labour operation and its effect on Port throughput.

1.1 Port Chalmers: Forest Products Exports

Port Chalmers lies on the Otago Peninsula, 12 km north of the city of Dunedin. Its principle hinterland is the province of Otago. There is a considerable forestry resource in this region and it is envisaged that the export of the forest resource (in whatever form) will have a significant impact on the Port.

The Port consists of two facilities, a container terminal of one berth and a general cargo berth (Beach Street Wharf). The container terminal is a single berth

with two standard container cranes. It can handle ships with a draught up to 10.6 m and is geared up to operate on a twenty four hour basis.

The Beach St wharf was originally designed to service general cargo ships, but has recently been earmarked to be the basis of a forest products export facility (in fact all recent forest products throughput has been over the Beach St wharf).

When designed it was thought that the berth would provide two high quality overseas berths, due to increases in ship sizes this has changed somewhat and it can really only provide for one overseas ship to be serviced at any one time. The berth can handle vessels up to 9.8 m and with a length of less than 229 m (vessels over this length are considered individually). Beach St has chiploading plant as well as a considerable backup area for chip and log storage. It also has a consolidation depot (covered storage) which could be used for storing sawn timber.

The harbour itself is deep and can handle most vessel sizes without further dredging, it is thought that channel depth and width will pose little problems for larger ships. (See Maps 1 and 2)

Forestry exports commenced in July of 1969, after a combined effort by the Otago Harbour Board (OHB) and the Dunedin City Corporation (DCC) to ensure that logs grown in Otago were shipped through an Otago port, not Bluff (which was the intention of the New Zealand Forest Service). From that time the export of logs has represented a significant annual tonnage of throughput. The trade has been marked by fluctuations in markets however.

The present OHB policy is to

'seek recognition in both the regional scheme and the National Ports Plan that the deep water requirements of the Port Chalmers Container Terminal offers the most economical solution to the provision of port facilities to service the log/woodchip vessels in excess of 9.1 m draught.'

source OHB pes comms

1.2 Why Port Chalmers?

It is a major assumption of this report that the majority of forest products grown in the Otago/Southland region could be exported through a single port, Port Chalmers. The Otago/Southland region contains three major ports; Oamaru, Port Chalmers and Bluff, only these latter two have any significant forest resource located near them. The present policy of the NZ Ports Authority is

'the National Ports Plan relative to forest produce has been to allow Port Chalmers and Bluff to provide the necessary wharf facilities, including reclamation where necessary and for the National Ports Plan to adopt the Government policy of refraining from directing the use of any particular port. Thus the shipping and industry interests will utilise the port that is the most convenient and economical for

the particular trade being handled.'

(OHB pers comms)

Although Government policy appears to be against creating specialist port facilities there are a number of reasons why Port Chalmers is likely to become a major forest products export port.

- (1) It is easier to carry out large scale development at one site as it concentrates requirements for skills machinery, materials and finance in one area, creating economies of effort.
i.e. There is already some investment in forestry plant and forest products handling at Port Chalmers, to a much greater degree than at Bluff.
- (2) Port Chalmers is located near the major population center of the Southland/Otago region, thus there exists a wider range of services available for backing up Port operations, e.g. marine engineers etc.
- (3) There are significant economies of scale in concentrating forest products in one place and shipping from there. These economies of scale also exist in concentrating of shipping at one point.
- (4) The ports container facilities require sufficient draught to allow large container ships to be serviced. Forest products carriers can take advantage of this to increase the amount of throughput being carried by an individual ship.
- (5) Most importantly the Otago Province has a significant proportion of the Otago/Southland regions forestry resource, due to (a) the insistence of the Regional Councils etc current feeling is that forest products

grown in the region should go through the regions ports and (b) there are considerable savings in transporting the products to Port Chalmers as opposed to Bluff (see appendix 1).

- (6) By concentrating forest products exports at one place there is a significant increase in loading rates and decrease in costs as loading gangs become more familiar with the product and loading operations. This is clearly seen when comparing tonnes per Gross Gang hour in log loading at Mt Maunganui and other New Zealand Ports (except Nelson). Those specialising in forestry exports have a much higher loading rate. This implies that a concentration of forestry throughput will reduce loading costs rather than a dispersed series of forestry export ports.
- (7) Although at present only being examined, there is a considerable resource of lignite coal in Southland. If export of this resource occurs the closest port is Bluff and so there could be serious congestion problems between forestry and coal trades.

Due largely to the above points and the familiarity of Port Chalmers with the export of forest products, it is proposed that the Port be the main export port for forest products in the Southland/Otago region.

1.3 Why Log Exports?

This study concentrates on exporting chips, logs and sawn timber (including plywood) which is in conflict with the current Government policy of exporting value added or processed products.

It is felt that there is sufficient justification for this. The forestry Development Plan for the Otago Planning District (1974) found

'The study showed that purely from a commercial forest growing point of view export log production especially on a 30 year rotation was the most profitable development with an IRR expressed in constant money terms of about 7-10% for supplying wood to an integrated sawmill/refiner groundwood plant.'

'If forest production for a sawn timber/pulp investment is pursued in preference to log exports the forest grower incurs quite a substantial loss in revenue foregone.'

At present the most profitable forest products trade is the log export trade. It is unreasonable to assume that in having a large forest resource that one has an automatic comparative advantage in processing. In N.Z. (with exceptions) there is a relatively inefficient sawmilling industry which coupled with very high labour costs (relative to such places as Japan, Korea and Taiwan) which tend to significantly degrade any advantage in having an abundant and cheap resource.

The predominant reason for processing the product in N.Z. is that 1) it is worth more 2) it provides employment. Both of these statements can be difficult to prove. So far log exports have proven to have a higher IRR than processed products (i.e. 11% for logs compared to 7% for industrial development) and there is considerable cost involved in establishing a processing option. As far as labour is

concerned increasing technological sophistication has tended to reduce labour requirements (it also must be remembered that harvesting the resource etc will considerably increase employment).

There are also a number of other factors to consider which disadvantage processing.

- (1) Processing is energy intensive - the costs of energy is increasing continually often causing large increases in processing costs. There is a limit to the amount of energy available in N.Z. as the supply decreases costs increase. There will be major competition for limited energy resources in the future (timber processing is energy intensive, e.g. mechanical pulp).
- (2) The nature of the Southland/Otago resource, the P. radiata of this region has a low density. It isn't suitable for many forms of paper making, i.e. there are limits to its use. This is especially the case if Kraft Mill operations are considered. It is thought to be uneconomic to pulp trees of this region by this method.
- (3) There is increasing resistance to large scale processing plants in the region, e.g. recent controversy over the proposed Aromoana smelter, similar problems could arise with regards to large sawmill complexes and especially pulp mills.

For these reasons it is believed that forest growers in the region will opt for the higher gains to be made from unprocessed exports. This approach will probably be reinforced by the DCC, OHB and the Regional or United

Councils who *WISH TO* see the benefits accrue to the region as opposed to the Nation.

1.4 Projected Throughput 1986 → 2005

The 1981 forestry conference saw a great deal of work on the part of various working parties to try and predict the future resource and its effects on infrastructure.

The Industry Working Party came up with a series of four development scenarios for expected export outturn. One of these options forms the basis for the projected throughput of Port Chalmers for the purpose of this study (appendix 2).

TABLE 1 PORT CHALMERS THROUGHPUT 1986-2005

	(000's m ³) (per annum)			
	1985-90	1991-95	1996-2000	2000-05
Logs	13	200	777	215
Chips	111	111	171	639
Plywood	-	-	96	288
Sawntimber	-	-	-	363

source Proceedings 1981 Forest Conference

2. DESIGN PARAMETERS

To be effective in exporting a product it is necessary to transfer the products as quickly and efficiently through the port and onto the ship to reduce to a minimum the waiting time and hence the costs involved in keeping ships waiting for servicing.

The problem faced by Port Chalmers is that the present facility, the Beach Street Wharf will be unable to cope with the projected throughput without subjecting shipping to costly delays as a result of ships having to queue to receive service (i.e. loading). To discover when these problems start and a pattern of development that will reduce them it is necessary to evaluate a number of options that affect that rate of throughput clearance. These options are based on a number of factors which must be considered to provide a measure of the degree of congestion that is likely to be experienced. The important factors are; labour, shipsize (related to harbour draught) and the number of berths available to transfer forest products.

The aim of all port operations is to reduce the time spent by ships waiting for service. The costs of waiting for service is transferred to the exporter in terms of higher freight rates etc. Waiting costs can be significant where there is a large amount of congestion in a port.

2.1 Options

There are four options which consider the effects of labour, draught. The number of berths is thought to be a function of the former two and so that labour and draught

options will be evaluated against a number of berths.

- (1) 8 hr working day with the capacity to handle ships up to 9.8 m - this is essentially the existing situation (status quo) at Port Chalmers at present. 1/9.8.
- (2) An 8 hr working day plus a 12.2 m draught (this enables the largest projected forest products vessels to be handled). 1/12.2.
- (3) A 14 hr working day (2 shifts of seven hours each) plus a 9.8 m draught. This evaluates a faster loading option. 2/9.8.
- (4) A 14 hr working day plus a 12.2 m draught, essentially an optimum condition of the biggest ships being loaded at the fastest possible rate. 2/12.2.

2.2 Method

The purpose of these options is to determine the delays to shipping (i.e. waiting time) caused by using each option to load the predicted port throughput. The delays caused by each option and the cost of these delays can be calculated. The costs of these delays can be traded off against the annual capital cost of building a new berth where the cost of waiting for service is greater than the cost of providing the new berth. To carry out this analysis it is necessary to use a branch of Operations Research known as queuing theory (largely Erlangs formula) (appendix 3).

2.3 Queuing Theory

The basis of queuing theory lies in the fact that when you have a system providing a service, e.g. a port, there is often some waiting involved before that service can be carried out, i.e. waiting time. This waiting time can be calculated using Erlangs formula as long as two assumptions are made (1) interarrival times of ships are completely random (2) the service time (i.e. to load) is a negative exponential distribution.

Queuing theory predicts the delays to shipping as a result of port congestion. To apply this theory it is necessary to know

- (1) port throughput
- (2) the number of ships required to clear the throughput
- (3) service times, i.e. how long it takes to load a ship.

2.4 Shipping

In order to determine the number of ships required to clear the ports throughput it is necessary to know the characteristics of the ships that will be servicing the port. Present world trends are toward larger vessels (appendix 4) but there is an upper limit imposed on this growth by (1) the size of ship able to use the Panama canal and (2) the effects of the recent global recession. In this report two ship sizes are reviewed, a 9.8 m draught and a 12.2 m draught.

In evaluating the capacity of shipcarriers a larger carrier than usual was looked at (i.e. bigger than what normally loads at Port Chalmers). This was based on the latest generation ship carriers, Length = 170 m,

Breadth 28 m, Draught 9.2 m, Capacity 50000 m³.

The general characteristics of the other ships are in Table 2.

<u>TABLE 2</u>	<u>CAPACITY OF LOG AND TIMBER CARRIERS</u>	
Draught	Sawntimber	Log Cargo (000's tonnes)
9.8 m	12.1	11.8
12.2 m	30.4	34

source Nelson Harbour Development Plan 1981

After considering ship size it is necessary to determine the loading rate to find out how long it takes to load ships.

The rate of loading is dependent on (1) the ships lifting facilities, or those of the berth (2) the familiarity of the stevedores with loading the product.

2.5 Loading Rates

<u>TABLE 2.1</u>	<u>LOG LOADING RATE</u>		
	1981	1982	1983
tonnes/day	766	753	975

source Waterfront industry commission
Statistics (WIC)

There is an average loading rate of 831 tonnes per day. The present estimated average for N.Z. is 800 tonnes per day (CNIPS report number 7) therefore the lower figure of 800 tonnes per day will be taken.

TABLE 2.2SAWNTIMBER LOADING RATE

	1980	1981	1982	1983
tonnes/day	1656	1275	450	523

source WIC Statistics

average loading rate is 980 t/day.

This is extremely low compared to the N.Z. average (2000 t). There are a number of reasons why however.

- (1) Due to a declining amount of sawntimber exports there is a loss of familiarity with handling the product hence a lower loading rate.
- (2) There is unlikely to be any of the ships with sophisticated loading equipment calling at Port Chalmers e.g. Gearbulk carriers, so therefore the lower rates reflect the lower level of loading technology at the Port.

It is assumed that there will be an improvement in this rate as the quantity of throughput increases then so too will experience and more specialist timber carriers will call.

WoodChips

There are two assumptions made here.

- (1) The operation occurs over a 20 hour period.
- (2) There is continued usage of the chiploader at Port Chalmers.

TABLE 2.3CHIP LOADING RATES

	1980	1981	1982	1983
tonnes/day	5696	4564	5584	6684

average = 5700

There are a number of assumptions made with regards to converting the volume throughput to tonnes.

- (1) one m³ of log = 1 tonne
- (2) one m³ of chips = 1 tonne (assume green)
- (3) one m³ sawntimber = 0.55 tonne (dried timber)

Further consideration must be taken of the effect of working a 14 hr day (double shift). The predictions are based on CNIPS report number 7 and Nelson Harbour Development Plan and it is assumed that they will apply to Port Chalmers.

TABLE 2.4 LOADING RATES (DOUBLE SHIFT) (tonnes/day)

Logs	1500
Sawntimber	3300
Chips	5700

(source CNIPS Technical Report No 7)

2.6 Vessels Required to Clear Port Throughput

By looking at the capacity of forest products vessels it is possible to relate this to throughput and determine the number of ships required to clear the throughput (Table 2.5).

TABLE 2.5 VESSELS REQUIRED TO CLEAR PROJECTED THROUGHPUT

Draught	1986-90	1991-95	1996-2000	2001-05
9.8 m	3	19	74	73
12.2 m	3	8	34	36

3. BASIS FOR CALCULATIONS

The approach taken with regards to determining the effects on the Port is based initially on determining the percentage berth occupancy over a given time period (in this case 365 days).

Using this percentage it can be determined roughly where bottle necks occur (i.e. queues develop) then by using Erlangs' formula the delay in days can be calculated.

In its report on port requirements the CNIP study used an evaluation of berth occupancy to determine the effects on Ports. The study set an upper limit on berth occupancy, when this limit is exceeded then delays to shipping become excessive and extra berths are needed (Table 2.7)

TABLE 2.7

BERTH OCCUPANCY LIMITS

Port	Number of Berths	Occupancy factor (%)
Mt Maunganui	11	75
Napier	8	75
New Plymouth	8	60
Gisborne	1	45
	(2)	54

source CNIPS technical report
No 7.

From this table (2.7) it is implied that once a berth has a percentage occupation greater than 45 (i.e. Port Chalmers only has one forestry berth) then the costs of shipping delays outweigh the cost of providing a new berth. This approach is used with Port Chalmers to give an indication of when congestion problems are likely to occur.

4. RESULTS AND ANALYSIS

4.1 Berth Occupancy

Option 1/9.8		<u>Berth Occupation (%)</u>		
Berth No	1986-90	1991-95	1996-2000	2001-05
1	31	60	236	240
2	16	30	118	120
3	10	20	79	80
4	8	15	59	60

Option 2/9.8		<u>Berth Occupation (%)</u>		
Berth No	1986-90	1991-95	1996-2000	2001-05
1	11	41	137	147
2	6	21	69	70
3	4	14	50	47
4	-	-	34	35

Option 1/12.2		<u>Berth Occupation (%)</u>		
Berth No	1986-90	1991-95	1996-2000	2001-05
1	31	74	175	245
2	16	49	88	122
3	10	24	58	82
4	8	19	44	61

Option 2/12.2		<u>Berth Occupation (%)</u>		
Berth No	1986-90	1991-95	1996-2000	2001-05
1	11	42	91	127
2	6	21	46	64
3	4	14	30	43
4	-	-	23	32

These results provide an indication of when a new berth or berths need to be constructed to reduce problems of port congestion. It appears that the Beach St Wharf is able to handle the throughput for the period 1986-90, since the occupation is below the CNIPS limits, it seems as though it is best to keep a 1 shift operation going also, i.e. the best idea seems to be maintain the status quo.

The 1991-95 period presents problems in that for one berth with a single shift operation there are occupancy rates greater than CNIPS recommendations. This indicates that (1) there is probably a requirement for another berth during this period if a single shift loading operation is pursued.

(2) There are significant reductions in occupancy to be made if a two shift loading operation is used.

(3) There appears to be a disadvantage in using larger vessels, especially with a one shift loading operation.

From the results it appears the best option is to switch to a two shift loading operation. Draught appears to have little effect on berth occupancy, there are however effects in that the waiting costs for larger ships are much greater so delays to these vessels are much more costly. It appears that if a two shift loading operation is adopted then the cargo throughput in the 1991-95 period can be maintained over one berth.

1996-2000 - during this period the 1/9.8 option is unable to cope with less than two berths, i.e. in this case berth occupancy is greater than 100% even if two berths are used. In all other options occupancy is over 90% if

only 1 berth is used. This implies significant waiting. The double shift loading appears to be very significant in reducing berth occupancy. It appears necessary that at least one new berth is needed here, but concurrent to its development dredging the harbour to 12.2 m will be necessary, i.e. the best option in this period appears to be 2/12.2. Using this option gives a harbour with 2 berths dredged to 12.2 m with a double shift loading operation. It appears that as throughput increases plus a faster loading rate larger ships become a more efficient proposition.

2001-05 - if wishing to maintain an efficient system, i.e. without significant congestion then for a one shift loading operation it appears necessary to have four berths at a minimum. A double shift loading operation considerably reduces the berth occupancy and it is possible to use only three berths. There appears to be little benefit in having large ships unless a two shift loading operation is used but even then the difference is only a few percent. At this stage there is little difference in having a three berth complex with 9.8 m or 12.2 m draught as long as there is a double loading option.

4.2 Waiting Time - Delays to Ships in Days

The berth occupation percentage give some indication to the degree of usage and possible times of congestion. The real need however is to evaluate the time (in days) spent waiting for service. Two assumptions have been made.

- (1) For any berth occupancy (%) greater or equal to 100%

it is assumed that the waiting time is so great that the best option (i.e. infinitely large) is to build a new berth.

- (2) In cases where berth occupancy is less than or equal to 20% it is assumed that delays to shipping are inconsequential.

Option 1/9.8		<u>Ship Waiting Time</u> (days)			
Berth No	1986-90	1991-95	1996-2000	2001-05	
1	N	228	-	-	
2	N	22	-	-	
3	N	N	764	837	
4	N	N	138	179	
N = Negligible delay					
- = very large delay					
i.e. > 100% occupancy					

Option 2/9.8		<u>Ship Waiting Time (days)</u>			
Berth No	1986-90	1991-95	1996-2000	2001-05	
1	N	47	-	-	
2	N	7	390	418	
3	N	N	75	59	
4			10	11	

Option 1/12.2		<u>Ship Waiting Time (days)</u>			
Berth No	1986-90	1991-95	1996-2000	2001-05	
1	N	216	-	-	
2	N	17	2030	-	
3	N	N	186	1088	
4	N	N	33	156	

Option 2/12.2	<u>Ship Waiting Time</u> (days)			
Berth No	1986-90	1991-95	1996-2000	2001-05
1	N	49	-	-
2	N	N	78	275
3	N	N	11	44
4	N		2	8

A number of conclusions can be drawn from these waiting times which tend to confirm what has been found in the berth occupancy figures.

- (1) It appears with large forestry throughputs it is necessary to have a two shift loading operation.
- (2) Draught appears to have very little relevance with a two shift operation, however there are considerable problems with delays with large ships but only one shift loading.

4.3 Costs

To determine the best option it is necessary to work out the cost of each factor, i.e. labour, waiting costs etc and then determine the cost of each option in terms of losses due to queuing.

There are two major components in costing the delays to shipping. These are

- (1) The cost of labour, more specifically the cost of a double shift loading operation, and
- (2) The cost of keeping a ship waiting until a berth is free so the ship can be serviced (appendix 5).

4.3.1 Labour Considerations and Costs

As berth occupancy increases due to port congestion

there are costs incurred by the exporter as a result of the ships being forced to wait ~~ie~~ waiting cost. The best method of reducing this waiting cost appears to be to shift loading operations into a two shift (two of 7 hrs) loading operation. This enables greater volumes of cargo to be loaded in a shorter time and this tends to set back the time for when new capital investment is needed to develop further facilities. There is a problem though with increasing the number of shifts worked. There is a considerable increase in labour costs which can possibly reduce the significant savings in waiting costs made by a two shift loading operation.

There is only one loading operation in N.Z. ports at present that comes close to a two shift loading operation. That is the Port of Napier's 'all in pulp contract'. There is of course a difference between loading pulp and logs but this will give some indication of the potential increase in costs as a result of a two shift loading operation.

To determine the extra cost the difference is taken between the 'all in pulp contract' (total average cost per tonne) and the total average cost per tonne for logs and sawn timber at Port Chalmers. This difference is then multiplied by the port throughput to determine the extra cost of a two shift operation.

Sawn Timber

Operation	Hours	Labour Cost \$/tonne (source WIC)
1 shift	8	6.11
2 shift	14	9.29

Difference = \$3.18

Logs

Operation	Hours	Labour Cost \$/tonne (source WIC)
1 shift	8	7.14
2 shift	14	9.29

Difference = \$2.15

Chips are already loaded at an extended hours rate and so these costs are assumed to be constant and are not considered.

Labour Costs for Two Shift Loading

	1986-90	1991-95	1996-2000	2001-05
Cost (millions of dollars)	0.028	0.430	1.82	1.58

These costs are added to those of ship waiting costs in the options with a two shift loading operation.

4.3.2 Ship Waiting Costs

Ship waiting costs (\$'s/day)		
Draught	9.8	12.2
Cost	10909	14314

4.3.3 Total Waiting and Labour Costs

These are calculated by multiplying the delays in days to ships by the ship waiting costs which gives the total waiting cost for a period, if a two shift operation is also involved then the labour cost must also be added in.

Option 1/9.8 Total Cost of Delays and Labour (\$'s millions)

Berth No	1986-90	1991-95	1996-2000	2001-05
1	-	2.487	X	X
2	-	0.242	X	X
3	-	-	8.240	0.041
4	-	-	1.393	1.841

- cost is minimal and not considered

X cost assumed to be very large and an additional berth gives large savings

Option 2/9.8 Total Cost of Delays and Labour (\$'s millions)

Berth No	1986-90	1991-95	1996-2000	2001-05
1	0.028	0.943	X	X
2	0.028	0.508	6.075	6.140
3	0.028	0.430	2.638	2.224
4	0.028	0.430	1.918	1.700

Option 1/12.2 Total Cost of Delays and Labour (\$'s millions)

Berth No	1986-90	1991-95	1996-2000	2001-05
1	-	3.522	X	X
2	-	0.243	29.057	X
3	-	-	2.662	15.574
4	-	-	0.472	2.233

Option 2/12.2 Total Cost of Delays and Labour (\$'s millions)

Berth No	1986-90	1991-95	1996-2000	2001-05
1	0.028	1.131	X	X
2	0.028	0.432	2.938	5.518
3	0.028	0.430	2.978	2.210
4	0.028	0.430	1.849	1.695

4.4 Analysis of Costs

From this cost data it is possible to construct a possible development based on minimising the total cost.

1986-90 since the waiting costs have been assumed to be zero then the only costs are those to do with labour. These costs or lack of them don't mean the best option is to reduce later costs by building new facilities immediately so these costs will be significantly less than the annual capital costs of providing a new berth.

The best result (i.e. the maximum cost) appear to be in 2/9.8 and 2/12.2 (at least by 2001-05).

The effects of two shift labour is substantial in that it raises the costs of the two shift operations almost to the level of the 1/9.8 option in 2001-05 (4 berths) at this time the 1/9.8 option has 179 days waiting compared to 11 and 8 days delay for 2/9.8 and 2/12.2. The implications are that labour costs will be increasingly important in the costing of port operations and could become an even more significant feature in the costs of handling.

It is also apparent that by maintaining a large draught but only a single shift loading operation costs

become excessive. This suggests that if economies of transport are sought in using large ships that a two shift loading operation will be required to effectively service these ships but labour costs significantly reduce these advantages lowering them to the level of a smaller ship size with either a two or single shift loading operation.

From the point of view of reducing costs it appears that for 1986-90 that a status quo approach is observed (i.e. just use the Beach St berth with a single shift), however prior to 1991 provide an additional berth which is 9.8 m draught and worked on a single loading shift so that in 1991 to 1995 there is 2 berths.

During 1991-1995 it will be necessary to provide a further berth and at the same time dredge every berth to a depth of 12.2 m and institute a two shift loading operation. This is for the next period 1996-2000. It may be wise to provide a fourth berth during 1991-95 to further reduce costs in 1996-2000 (this will depend largely on the cost of providing the new berth).

So for 1996-2000 there will either be three or four berths depending on the annual capital replacement cost. If the tree berth only option is taken then a fourth berth would need to be provided to cater for 2001-05.

By 2001-05 there should be four berths plus a two shift loading operation all dredged to 12.2 m. This process minimises the costs of waiting and labour but takes no account of the use of annual capital replacement cost for a new berth.

No more than four berths have been looked at as the space available is strictly limited and four berths would be the maximum.

5. THE COST OF EXPANSION

It is difficult to determine the costs of any projected expansion without a major investigation into the engineering and environmental aspects.

'Unfortunately there is no clear indications of how the forest resource will be utilised in the future and this inhibits any detailed planning of port facilities.'

(OHB pers comms)

By necessity the predicted costs are general and in no way give a precise costing of expansion but rather indicates approximately how much the projects will cost.

The first piece of expansion is a new berth to complement the Beach St facility. This berth can probably be established with very little cost because all the necessary reclamation has been carried out. There is only a need to construct a quay plus its ancillary plant. Some dredging will be required to obtain an adequate depth of water for this berth.

The 1981 study of Nelson Harbour indicated that a new quay would cost somewhere in the order of \$2.7 m (1981 \$) all up including dredging etc the cost for a complete new berth was \$5 m (1981 \$). This is probably similar to the cost of a new berth at Port Chalmers so this figure will be used as the cost. This is converted to a 1984 cost by using a CCI of 1520, therefore the cost of the first berth built at Port Chalmers will be \$7.6 m.

The other costs are drawn from the following table.

TABLE 2.8 PROJECTED COSTS FOR NEW FORESTRY BERTHS

(\$'s m 1981 costs)				
Item	1st	2nd	3rd	4th
Berth	10	10	10	10
Dredging	8	6	5	4
Breakwater	7	5	5	4
Other	11	6	6	5
Total	36	27	26	23

(source McLeod 1981)

'The figure of \$10 m used in Table 2.8 is based on Bay of Plenty Harbour Board records. It is possible that the latter figure is a total of actual contract payments and contains allowances for escalation over a three year construction period. Real cost should be in order of \$8 m.

(pers comms Hunter from McLeod)

The provision of the next berth (to give the third berth) will involve a greater cost than the first berth constructed because considerable dredging is required (deepening all berths to 12.2 m). In this case the cost is taken from the second column of Table 2.8 except there is no breakwater and the other is reduced by half to account for the plant etc it represents already being present at Port Chalmers.

Berth \$3 m this cost has been reduced substantially to a cost similar to Nelson. This assumes that the berth is primarily a quay structure.

Dredging \$6 m

Other \$3 m

\$12 m (1981) for the next berth

or converting to 1984 figures some \$18 m.

The provision of the final berth will be less costly than the second as the majority of the dredging will be done and most facilities in place.

The dredging costs are assumed to be low because all areas except the new berth site will be a 12.2 m depth, therefore the dredging will be limited.

Berth \$3 m

Dredging \$2 m

Other \$3 m

= \$9 m

using a CCI of 1520 this comes to \$13.68 m.

If the berth is assumed to have a life of fifty years and a capital repayment rate of 15% then on an annual cost basis

the first new berth = \$1.14 m

the second berth = \$2.70 m

the third berth = \$2.05 m

5.1 Implications of the Cost Data

By using the cost of new berths as constraints it is possible to discover the best cost option.

1/9.8 in 1991-95 waiting costs exceed the cost of a new berth so a new berth can be constructed for this period which reduces the waiting costs in this period to \$0.242 m, i.e. move to Berth No 2 for

loading at the waiting cost.

There are now problems with evaluating the rest of this option as there are unknown values, it can be assumed that there are considerable savings to be made so a further two berths will be constructed (to give 4) for 1996-2000 and 2001-05 with waiting costs of \$1.393 m and \$1.841 m respectively.

2/9.8 With this option the waiting costs don't exceed the berth replacement cost until 1996-2000, again assuming very large costs it is probably best to build all berths prior to this period so for 1996-2000 and 2001-05 the waiting costs have been reduced to \$1.918 m and \$1.700 m respectively.

1/12.2 In 1991-95 the waiting costs exceed those of constructing a new berth so a new berth can be constructed prior to this again costs exceed those of replacement in 1996-2000 so a further two berths can be constructed to give waiting costs of \$0.472 m and \$2.233 m for the last two periods.

2/12.2 This option can not build until just before 1996 as it isn't until this period that the waiting costs exceed the costs of port construction. However in 1991-1995 the savings are so great for the following period that three berths can be built giving a waiting cost of \$1.849 m and \$1.695 m for the last two periods.

All this has really implied is that the increases in throughput are dramatic and that in some cases there is a demand for greater than one berth being constructed in a year. It appears that the congestion problems are so severe that there are considerable savings to be made in constructing several berths at once.

All come to the conclusion that by 2001 at least four forestry berths are needed and those with a two shift loading operation tend to have lower waiting costs than those with a single shift operation.

No one option stands out as best and it appears that the best results could be obtained by mixing development and moving in graduated stages as opposed to the sudden changes in berth numbers indicated in a comparison of berth replacement costs and waiting costs.

The question must be asked whether the port is to serve its own interests (i.e. make sure that the provision of further facilities is profitable) or those of the exporters who require a fast and efficient throughput to effectively trade their product.

As no one option appears to stand out as the most suitable one it is therefore proposed that any development plan be based on savings in waiting costs as opposed to being written off against the annual replacement capital cost. From the cost data it can be seen that the Port will need a minimum of four berths by 2001 to effectively handle the forest throughput. In all cases the predicted congestion has considerable cost which in most cases is greater than the predicted cost for new berths, it is therefore felt that development should follow similar lines to that proposed earlier.

- 1986-1990 - status quo, 1 berth (Beach St)
1 shift loading option
- 1991-1995 - 2 berths, 9.8 m draught
1 shift loading operation
- 1996-2000 - 3 berths, dredged to 12.2 m
2 shift loading operation
- 2001-2005 - 4 berths, 12.2 m draught
2 shift loading operation

There is a two to three year lead time before a new berth can be fully utilised so the times when construction should begin are

- 1988/1989 - 1st new berth should begin
- 1993/1994 - the next new berth should start
- 1998/1999 - the final berth construction should start.

It is necessary that these lead times be strictly met as there are considerable costs involved if the Port is unable to effectively clear its throughput.

6. CONCLUSION

Port Chalmers faces a tremendous increase in the throughput of forest products. This will create serious congestion problems by the mid 1990's. In evaluating the ability of the Port to handle this large throughput it was found that

- (1) There was the need for three new berths by 2001 to effectively load the throughput.
- (2) Ship size isn't important in clearing the throughput as long as double shift loading operation is used. In fact large ships with slow loading represent a liability. There is little difference in the waiting costs of vessels of 9.8 m and 12.2 m draught as long as there is double shift loading. It is important to note that there is an increasing trend to larger ships and there must be consideration of a Ports ability to handle these ships. Port Chalmers in this respect is lucky in that it can easily take large ships.
- (3) Labour is the most important component of any forestry port. To effectively clear large throughputs a double shift loading operation is needed. This will significantly reduce waiting times. There is however an associated cost which tends to reduce the advantages of faster loading. It is felt that Port Chalmers should by 1996 be instituting a two shift operation and thus the Port must be able to handle 24 hr operations. This is already done at the container terminal so it can be expanded to forestry as well.

It appears there needs to be significant changes to the Port Operation in order to cope in the 1990s. There are problems with planning port development with regards to forestry in N.Z. as the forest owners have as of the moment not provided those who control the infrastructure actual decisions on the products to be shipped etc. This creates problems in that it is difficult to plan for specific forest products exports.

Time however is running out. The first berth required at Port Chalmers is to be begun in 1988 or 89, a pulpmill requires a considerable lead time. Decisions on the future export product mix need to be made rapidly to ensure the infrastructure is capable of handling it.

Acknowledgements

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APPENDIX 1Location of the Resource

The reason for all projected forest products exports going through Port Chalmers is that the majority of the resource is located within the boundaries of the Otago Planning District.

Otago vs Southland Total Log Volume (000's m ³)					
	1981/85	1986/90	1991/95	1996/2000	2001/05
Otago	323.8	336.5	482.2	1204.1	2046.8
Southland	142.4	158.8	192.1	585.3	1062.7

(source Levack 1981)

From this it can be seen that a considerable amount of the resource lies within Otago and for the following two reasons the entire resource of the Southland/Otago region will probably go through Port Chalmers.

- (1) There is a large processing facility projected for Balclutha. It is a central location for the bulk of the resource in both Southland and Otago, yet it is only 92 km from Port Chalmers. If this area processes the entire regions forest products and it is closer to Port Chalmers than Bluff it is highly likely that the products will be shipped through the closest port.
- (2) Since the Otago province has the bulk of the resource it is envisaged that local government and other bodies will lobby to have the forest products exported through the regions main port, i.e. Port Chalmers. Since the bulk of the resource lies in Otago then by having it shipped through Port Chalmers will increase

specialisation and hence efficiency and will probably be able to offer better services than other relatively unspecialised ports, i.e. Bluff and Oamaru.

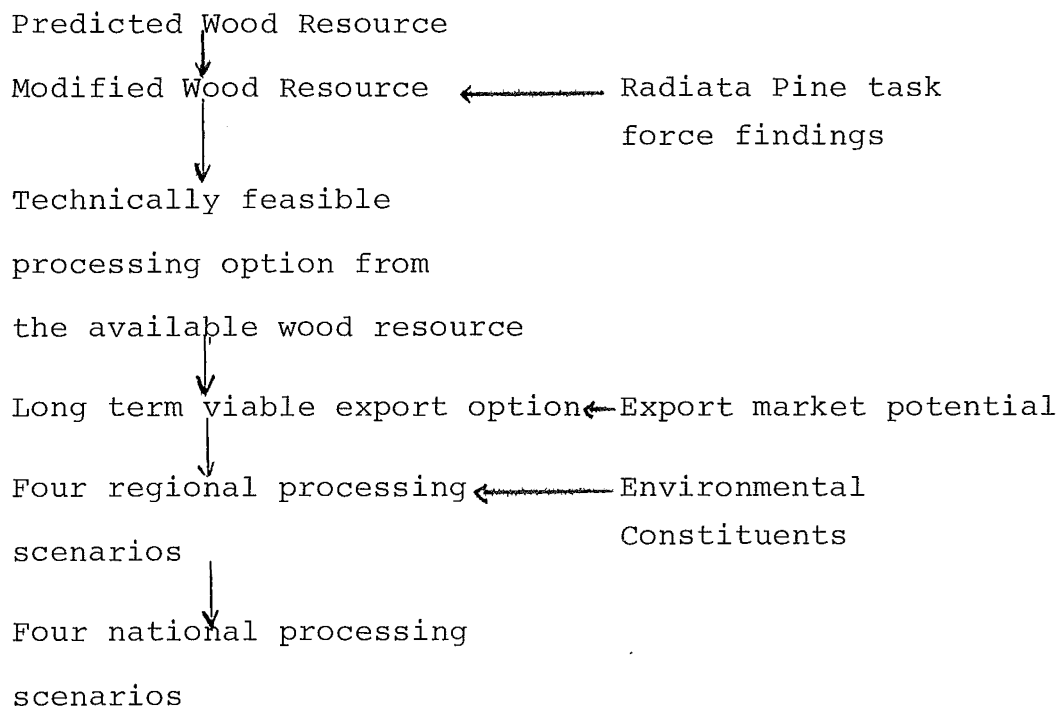
APPENDIX 2

Port Throughput

The projected throughput used in this report has been developed by the Working Party on Processing Options which presented their report at the 1981 Forestry Conference.

The basis for their programme was to cater for the existing processing options. The surplus wood left over was then used to develop the four processing scenarios.

The development of the processing scenarios is based on the following pattern.



APPENDIX 3Queuing Theory

Queuing is used to describe a system where some type of service is provided and there is a waiting time for the service involved. When queuing theory is used with regards to shipping patterns there are two assumptions.

- (1) The arrival of a ship in port is random (i.e. can't be accurately predicted).
- (2) When a ship arrives in a port, it may be able to move directly to a berth, or it may have to wait until the berth is unoccupied prior to it moving in and being serviced.

These two assumptions create the basis of queuing theory, i.e. that delays can occur to units as a result of being forced to wait while some other unit is serviced. The arrival rate of ships is assumed to be random (it follows a poisson distribution) and the service time at a berth follows a curve known as a K curve (there is a large series of these curves) which tends from 1 to infinity. As K gets larger then the service times become uniform while when K approaches or equals one the service time follows a negative exponential distribution. The adoption of a $K = 1$ curve allows the use of Erlangs formula to calculate the delays to shipping.

There are a number of factors required before Erlongs formula can be used. These are (1) average arrival rate (i.e. the number of ships arriving in 365 days) and (2) the average berth occupancy (percent).

Both (1) and (2) are used to calculate the traffic intensity which is used in Erlangs formula.

The average berth service time (the time it takes to load a ship) and the number of vessels required to clear a port throughput are also needed in the analysis.

N = number of effective berths in the port being analysed as a single unit

n = total number of ships arriving over a period of 365 days

λ = the average arrival rate of ships

T_w = average waiting time for all ships during the study period

θ = average berth occupancy (%)

W = traffic intensity

Formulae

$$(1) \quad \lambda = n/365$$

$$(2) \quad \theta = \frac{100\lambda T_b}{N}$$

$$(3) \quad W = \frac{N\theta}{100}$$

Erlangs Formula

$$\frac{T_w}{T_b} = \frac{W^N}{N(1-W)W^N + N.N.'(1-W)^2(1+W + W^2 + W^{N-1})}$$

Having determined the ratio $\frac{T_w}{T_b}$

$$\text{i.e. } \frac{T_w}{T_b} = X$$

$$T_w = XT_b$$

Having found T_w you can then determine the total waiting time by

$$T_w \times n = \text{total waiting time}$$

i.e. it is the average waiting time multiplied by the number of ships within a 365 day period.

APPENDIX 4

Trends in World Forestry Shipping

It is important to analyse trends in ship size and capacity as the larger the ship, the more it can carry but it has a longer loading time and less ships are required to carry a ports throughput.

Although affected by recent global recession it appears as though ship sizes, in all fields of forest products transport are growing.

Drewry (1979) concluded that continued growth in the bulk timber trade had led to more special purpose built lumber carriers in the 25000-30000 DWT class and recently 35-50000 DWT. Within N.Z. the trend towards larger ships is seen in the increasing use of the 'Gearbulk' class ships to carry pulp and sawn timber from Napier.

The major reason for the swing toward larger classes of ships is that the larger the ship the lower the cost/tonne for transporting the product.

Costs of Cargo on a range of vessels

DWT	18000	25000	35000	47000
\$/tonne	10.70	9.16	8.53	6.99

(1981 Costs)

This table shows the cost of transporting a forest product to Australia from Port Chalmers.

This is based on

$$C = \frac{VsDs}{Q} + \frac{Up}{p}$$

C = cost/tonne

Vs = vessel cost per day at sea

Vp = vessel cost per day in port

Ds = voyage days at sea

Q = cargo in tonnes

P = rate of cargo discharge
or loading

The figures in the table imply

For a given ship size and productivity cost is directly proportional to the length of the voyage.

For a given productivity, while time in port increases directly with vessel size, unit cost increases directly with vessel cost per day.

For a given voyage duration and productivity unit cost at sea decreases with ship size and unit cost in port increases with ship size.

These statements allude to the economies of scale that result from using larger ships. There are economies to be found in transport costs, i.e. a decrease in unit transport cost as carrier size increases, but when a large ship is lying idle in a queue or alongside a berth there are significant costs involved.

To make these vessels efficient a rapid service is required when they are in Port. The best option is probably a double shift loading operation.

The change in N.Z. to larger ship sizes have not been so dramatic as on major world trade routes but there has been some impact.

'log carriers in 1968/69 were carrying 50000 t where today they carry 15000 t and require a loaded draught of 10.7 m.'

(OHB pers comms)

It appears that over the next thirty to forty years N8 ports are going to be under increasing pressure to

service larger ships. It is expected that the ships carrying N.Z.'s forest products exports will be a minimum of 26000 DWT and up to 50000 DWT in the chip and pulp trade.

'the average tonnage of ships carrying forest products from N.Z. rose from 11000 DWT (1973) to 18000 DWT (1979).'

(Source WIC Statistics)

Trends in Bulk Carriers

Due to the development of effective port facilities (on both sides of the Atlantic and Pacific) there has been a widespread introduction of larger more specialised carriers, however on the U.S.-Japan trade routes there has been less use of large vessels, in general there has been a trend toward more specialised carriers, i.e. specifically sawn timber or logs, nothing else.

There are problems that once off major world trade routes the transition to these larger vessels is severely restricted by the size and facilities of ports (this is true of many of N.Z.'s ports).

It seems likely that a wide range of forest products carrying vessels will be utilised to enable ports to work efficiently in clearing throughput. However as port facilities become more sophisticated then the trend to larger shipping will occur.

APPENDIX 5Calculation of the Average Waiting Cost

The average waiting cost is the result of determining the waiting cost for each individual type of throughput, summing it and dividing it by the total service time.

$$WC = \frac{\text{Sum}(T_n W_{Cn})}{T_b}$$

T_n = product service time
 W_{Cn} = ship waiting cost
 T_b = total service time

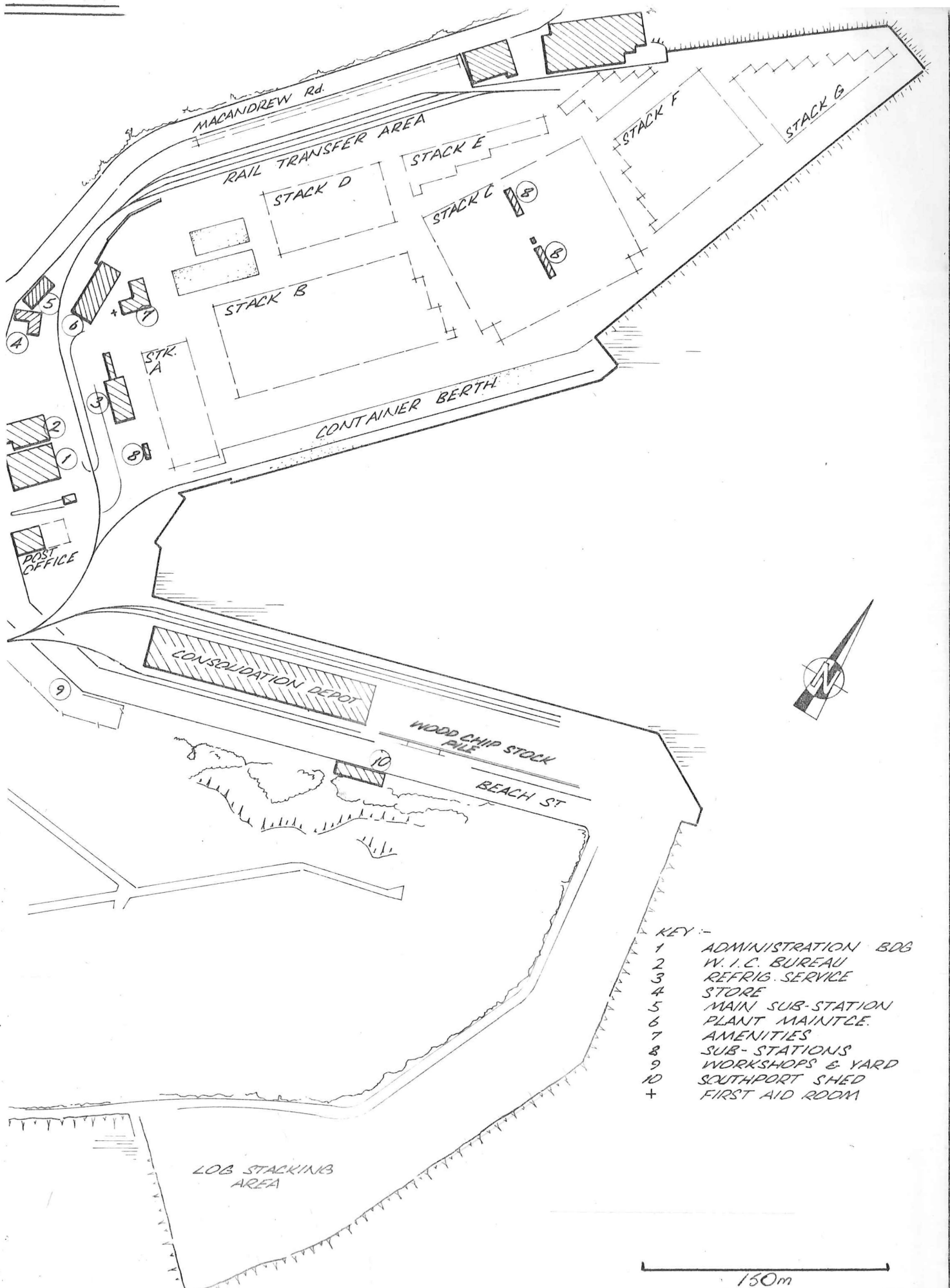
The ship waiting costs are taken from Nelson Harbour Board figures on the resource costs of shipping and have been multiplied by 12% to bring them closer to 1984 costs (i.e. predicted 12% inflation).

For 9.8 m draught

$$\begin{aligned}
 & (\$8300 \times 15) + (\$9500 \times 8) + (11700 \times 12) \\
 & \quad \text{log ship} \quad \quad \text{Chip} \quad \quad \text{Sawn/ply} \\
 & = \$340900/T_b \\
 & = \$9740 \\
 & \text{for 1984 costs } 9740 \times 1.12 = \$10909 \text{ per day}
 \end{aligned}$$

For 12.2 m draught

$$\begin{aligned}
 & (\$12700 \times 23) + (\$9500 \times 8) + (\$15900 \times 9)/T_b \\
 & = 12780 \\
 & \text{for 1984 : } 12780 \times 1.12 = \$14314 \text{ per day.}
 \end{aligned}$$



DRAWN:
M.E. THOMSON
30 JUNE 1983



OTAGO HARBOUR BOARD

PORT CHALMERS

A4

8447

Map 2

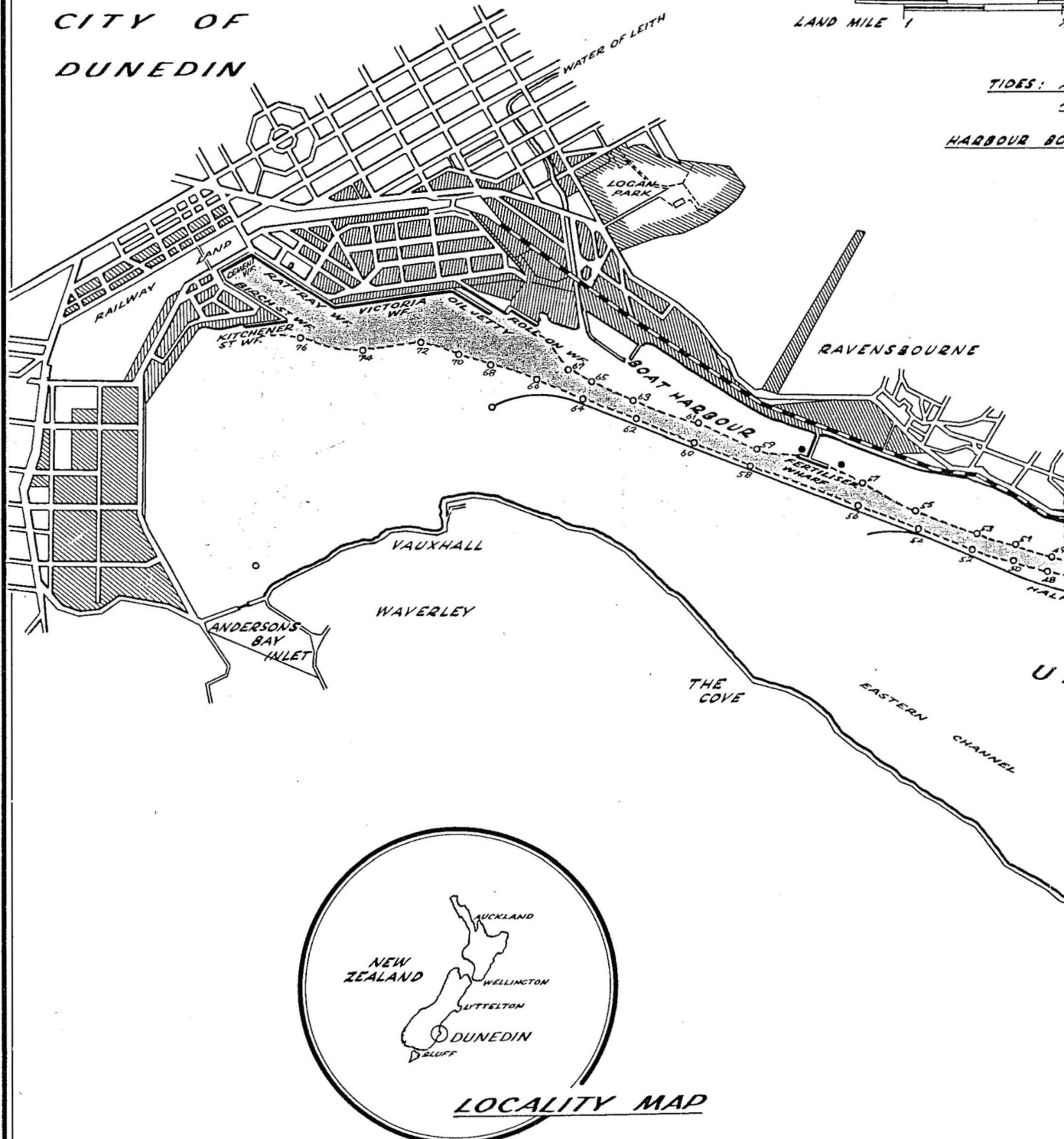
OTAGO HARBOUR N.Z.

DECEMBER 1979

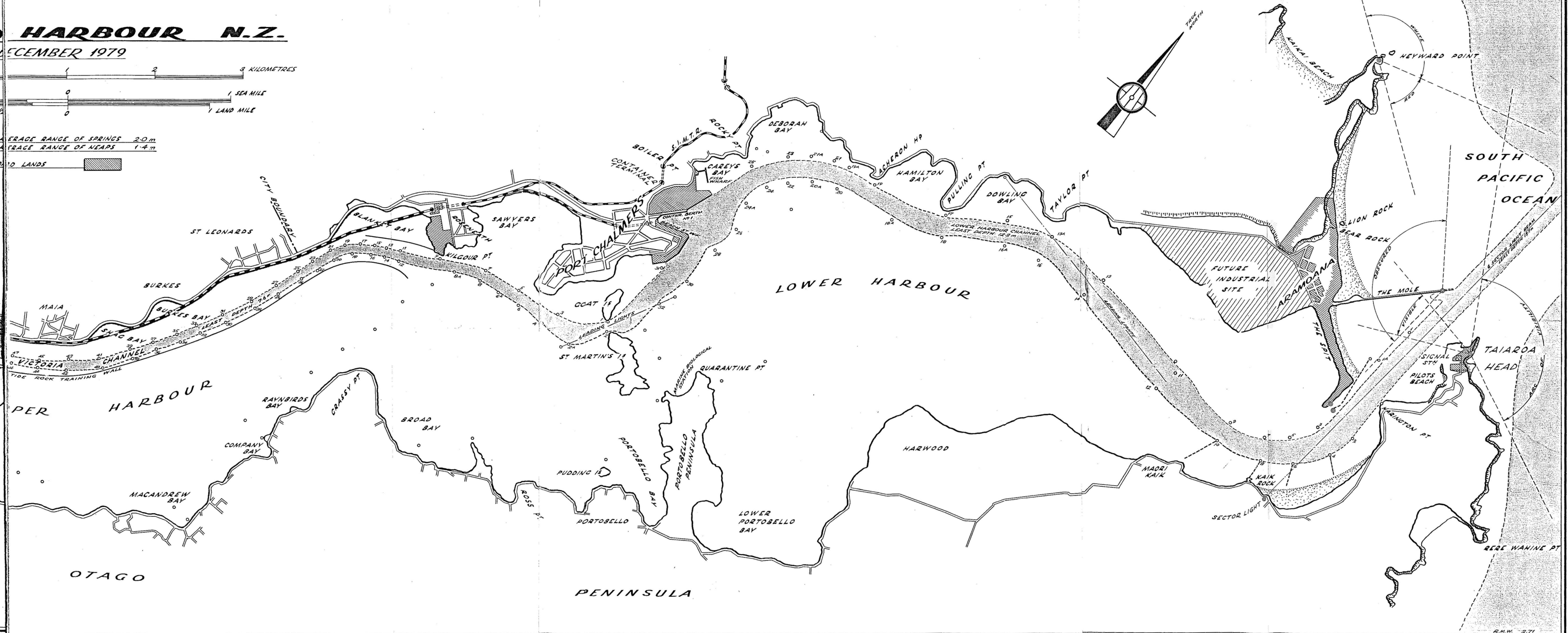


TIDES: AVERAGE RANGE OF SPRINGS 2.0m
AVERAGE RANGE OF NEAPS 1.4m
HARBOUR BOUND LANDS

CITY OF DUNEDIN



LOCALITY MAP



R.M.W. 2.71
REVISED 0.4.79
R.M.W. 10.75
R.M.W. 3.77
R.M.W. 5.77
R.M.W. 12.79